

STUDENT SUCCESS IN ELEMENTARY PHYSICS VERSUS THE
STUDENT'S CONCEPTUALIZATION OF THE ROLE OF
PHYSICS IN THE CURRICULUM

By

CHANPEN WANNARAT CHUAPHANICH

Bachelor of Education
Chulalongkorn University
Bangkok, Thailand
1967

Master of Education
Central State University
Edmond, Oklahoma
1972

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Thesis Approved:

Dellene L. Rutledge
Thesis Adviser
EE K. [unclear]
Mark R. Samuel
James G. [unclear]
Ken [unclear]
NN [unclear]
Dean of the Graduate College

964123

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TABLE OF CONTENTS

Chapter	Page
I. INTRODUCTION.	1
Background for the Study	2
Goals of the Study	4
The Physics 1114 (General Physics) Course.	4
Characteristics of Physics 1114 Students	5
Significance of the Study.	6
Limitations of the Study	8
Clarification of Terms	8
Basic Assumptions.	10
Organization of the Study.	11
II. REVIEW OF SELECTED LITERATURE	13
Introduction	13
The Status of the Elementary Physics Course.	13
The Role of Physics in Undergraduate Curricula	15
Physics in General Education.	15
Physics in Pre-professional Education	18
Physics in Engineering and Technology Curricula.	19
Factors Influencing Students' Success in Physics	22
III. RESEARCH DESIGN AND METHODOLOGY	27
Introduction	27
Development of the Research Instrument	27
Validation of the Research Instrument.	30
Measurement of Student Achievement	31
Research Procedures.	32
Administration of the Topic Inventory	32
Scoring of Inventories; Classification of Students	33
The χ^2 -Test	34
IV. ANALYSIS OF DATA AND RESULTS OF STUDY	37
Introduction	37
Statement of the Experimental Hypotheses	37
Analysis of the Data	40

TABLE OF CONTENTS (Continued)

Chapter	Page
Summary of Student Data.	40
Summary of Instructors' Responses.	44
Summary of Academic Advisers' Responses.	44
Tests of the Experimental Hypotheses	44
Summary	62
V. SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS.	64
Summary	64
Conclusions	65
Recommendations	68
A SELECTED BIBLIOGRAPHY.	70
APPENDIX A. TOPICS IDENTIFIED AS REPRESENTATIVE OF TC, LA AND PL TYPES OF COURSE.	74
APPENDIX B. PHYSICS 1114 -- A TOPIC INVENTORY	78
APPENDIX C. SAMPLE OF LETTER TO PHYSICS INSTRUCTORS	85
APPENDIX D. COLLEGE PHYSICS INSTRUCTORS PARTICIPATING IN THE STUDY	87
APPENDIX E. LETTER TO ACADEMIC ADVISERS	89
APPENDIX F. LIST OF ACADEMIC ADVISERS RESPONDING TO TOPIC IN- VENTORY	91

LIST OF TABLES

Table	Page
I. Number of Students in Each Conceptual Group.	41
II. Grade Distributions of Students in Each Conceptual Group .	42
III. Incomplete and Withdraw Grades in Each Conceptual Group. .	43
IV. Chi-square Analysis of Grade Distributions; Students With Clearly Defined Conceptions of the Role of Elementary Physics Versus Students in UC Group.	47
V. Chi-square Analysis of Grade Distributions; Students With Clearly Defined Conceptions of the Role of Elementary Physics Versus All Other Students.	49
VI. Chi-square Analysis of Numbers of Satisfactory Grades Re- ceived by Students in Various Conceptual Groups.	50
VII. Chi-square Analysis of Laboratory Incomplete Grades; Stu- dents With Well-defined Conceptions of the Role of Ele- mentary Physics Versus Other Students.	52
VIII. Chi-square Analysis of Numbers of Students Withdrawing From Physics 1114; Students With Well-defined Concep- tions of the Role of Physics Versus Students Without Such Conceptions	53
IX. Chi-square Analysis of Grade Distributions of Students Who Share the Instructor's Concept of the Role of Ele- mentary Physics and Students Who Do Not (TC vs. PL). . .	55
X. Chi-square Analysis of Grade Distributions of Students Who Share the Instructor's Concept of the Role of Elementary Physics and Students Who Do Not (TC vs. UC).	56
XI. Chi-square Analysis of Grade Distributions of Students Who Share the Instructor's Concept of the Role of Elementary Physics and Students Who Do Not (TC vs. LA + PL + UC). .	57
XII. Chi-square Analysis of Grade Distributions of Students Who Share the Instructor's Concept of the Role of Elementary Physics and Students Who Do Not (TC vs. All But TC). . .	58

LIST OF TABLES (Continued)

Table	Page
XIII. Chi-square Analysis of Numbers of Satisfactory Grades Received by Students Who Share the Instructor's Conception of the Role of Elementary Physics and Students Who Do Not.	60
XIV. Chi-square Analysis of Numbers of Laboratory Incomplete Grades Received by Students Who Share the Instructor's Concept of the Role of Elementary Physics and Students Who Do Not	61
XV. Chi-square Analysis of Numbers of Students Withdrawing From Physics 1114; Students Who Share the Instructor's Concept of the Role of Physics Versus Students Who Do Not.	63

CHAPTER I

INTRODUCTION

The educational process has been defined, and its specific objectives identified, by numerous authors. Hutchins (23, p. 67) writes: "If education is rightly understood, it will be understood as the cultivation of the intellect".

Thus, he sees as an essential component of education the development of the intellect or liberal study. However, he excludes vocational training from the college walls.

A different emphasis is provided by McGrath (24, pp. xviii-xix) who speaks for general education when he says:

Hence, 'general' education, concerned with the problems all men have in common, is distinct from the 'specialized' training addressed to the differences among them.--general education aims at developing whole minds--.

Career education is another major source of educational objectives.

To Hoyt (22, p. 2)

the fundamental concept of career education is that all types of educational experiences, curriculum, instruction, and counseling should involve preparation for economic independence, personal fulfillment, and an appreciation for the dignity of work.

The educational goal is the preparation of the people for earning their living.

Paul Leonard (24, p. 14) sees the significance of both general education and specialized education. He says: "General education gives us the basic fundamental values and purpose of life. Specialized education

gives us the skills to carry it out".

Despite the diversity of views expressed above, there is general agreement that a prime function of education is the transmission of knowledge, values and skills from one segment of the culture to another. If one thinks of the educational process as one of transmission, then it would appear that a condition akin to impedance-matching in the physical sciences may exist. That is, the relative success of the educational process may be controlled in part by the existence or absence of a common shared understanding between the instructor and the student as to the role or function of the subject matter in the student's curriculum. This point of view is expressed most clearly by Bevan (7, p. 9) who writes:

One thing is certain: students and teachers live in the same world, are exposed to the same problems, and if they are responsive to the tasks in which they are enjoined, will know that they cannot succeed unless they work side by side with some clear understanding of what they are trying to achieve.

The purpose of this dissertation is to report the results of a study designed (a) to develop a preliminary form of an instrument for identifying a student's conceptualization of the role of elementary physics in the undergraduate curriculum and (b) to examine the relationship, if any, between that conception and the level of achievement in the study of physics.

Background for the Study

Numerous variables have been studied by many investigators who have sought answers to the problem of individual differences in course achievement; these include interest, ability, attitude, and motivational factors.

The achievement of students in a course is the desired outcome of learning. According to Lindgren (29), learning is the changes in behavior that result from interaction with the environment, and reinforcement is the basic event that makes learning possible. The environment and reinforcement are the stimuli or conditionings of learning which arouse or motivate the student to be interested in doing or not doing something. Motivation has been classified as intrinsic or extrinsic. Intrinsic motivation is defined as a state in which the individual wants to do or learn something for its own sake. It presents values which are directly satisfying. A student solving a physics problem because of his curiosity is intrinsically motivated. Extrinsic motivation is defined as a state in which an individual does or learns something not for its own sake, but as a means of obtaining some desirable goal. For example, a student taking a physics course as a means of doing well in engineering or technology is extrinsically motivated. Teachers will be able to use motivation more effectively if they know the interests and needs of the student, since interest arises from the satisfaction of needs and from the realization of ambitions.

The principles of learning mentioned above can be classified into two major families of learning theories: the stimulus-response theories and the cognitive theories. As summarized by Hilgard and Bower (21), the stimulus-response theorists tend to believe that some sort of chained muscular responses, linked perhaps by fractional anticipatory goal responses, serve as integrators of behavior sequences. They treat learning as a matter of connections between stimuli and responses. This implies a learning by means of trial and error, cause and effect, or reward and punishment. The cognitive theorists, on the other hand, more freely

infer central brain process, such as memories or expectations, as integrators of goal-seeking behavior. They emphasize problem solving as a means of learning. Stimulus-response theories and cognitive theories apply to different kinds of learning. Stimulus-response theory lends itself to greater precision and fits better with an over-all scientific approach in which human learning is just one part of the natural world. Cognitive theories, on the other hand, make more allowance for the power and flexibility of man's intellectual processes and the way which man deals with complex problems. As a result, some learning theorists recognize the contributions of both theories since they believe that more than one kind of learning can occur.

Goals of the Study

There are two primary objectives of this study. First, the development and testing of a preliminary form of an instrument to identify the role of elementary physics in the undergraduate curriculum as it is sensed by students, teachers and academic advisers concerned with the course. Second, to investigate whether or not the success of students in the study of elementary physics is related to the way in which they perceive the role of the course in their curriculum and the presence or absence of an accord between student and instructor as to the role of elementary physics in the curriculum.

The Physics 1114 (General Physics) Course

The Physics 1114 course is a four semester-hour general physics experience. It is offered at Oklahoma State University primarily for liberal arts and technology students. The course consists of three fifty

minute lecture-demonstration sessions per week and a laboratory program of two to three hours per week. A mathematics prerequisite of intermediate algebra is imposed and trigonometry is restricted to definition of the trigonometric functions and solution of the right triangle.

Textbook for the course is chapters one through sixteen of College Physics by Miller (35) and the emphasis is on the basic principles of elementary mechanics, wave-motion, and thermal physics. A second course dealing with electricity, optics and some aspects of "modern" physics completes the sequence. The laboratory utilizes an "open" format and normally requires two or three hours of student time each week. Students select conventional experiments from a series dealing with elementary mechanics, wave-motion and thermal physics. The lecture sessions in Physics 1114 are always conducted by members of the physics faculty; laboratory sessions are under the supervision of graduate teaching assistants.

Characteristics of Physics 1114 Students

During the Spring of 1974-75, there were approximately three hundred students enrolled in Physics 1114 at Oklahoma State University. Lecture sections averaged about fifty students each. There were more than twenty laboratory sections, with a maximum enrollment of 18 students per section.

Students participating in this study were enrolled in lecture sections 4 and 6 under the instruction of Professor Samuel and sections 2 and 5 under Professor Sonder. The responsibility for the laboratory sessions was divided among nine graduate teaching assistants. No attempt was made to control enrollment in any of these sections and, as a result,

the sample involved in the study may be assumed to be representative of the continuing enrollment in Physics 1114.

The students enrolled in Physics 1114 sections 2, 4, 5, and 6 come from several of the colleges of the University. The largest fraction of the students, approximately 40 percent, were enrolled in the Technical Institute of the College of Engineering. Approximately 29 percent were enrolled in the College of Arts and Sciences, 19 percent in the College of Agriculture, and 7 percent were in the College of Engineering. The remaining students were distributed among the College of Business Administration, the College of Education, the College of Home Economics and the Graduate College.

Approximately 38 percent of the students were freshmen, 35 percent sophomores, and 20 percent juniors. The remainder were seniors and graduate students. Some 83 percent of the students are male and 17 percent female.

Significance of the Study

The elementary physics course is required of a significant fraction of the college student body. Physics is basic to engineering technology, engineering, and many branches of science. In addition, liberal arts students are often required to complete one or more courses in the physical sciences. Physics is also an admission requirement for most of the American medical schools (34) and for all American dental schools (2). Therefore, a majority of students enrolled in elementary physics courses are present because of some type of requirement; either a broad general education requirement, a more narrow major-field requirement or as a specific prerequisite to other courses in which the student expects to

enroll. These requirements are established for a variety of reasons. Thus physics is sometimes pictured as: (a) a "tool" course presenting factual information without which the student cannot expect to succeed in subsequent courses; (b) a true liberal arts discipline concerned with the codification and explanation of physical law--a course akin to the study of natural philosophy; or as (c) a preparation for living in a technological world of ever increasing complexity.

The present research represents an attempt to investigate whether or not a student's relative success in elementary physics is affected by such factors as (a) the presence or absence of a clearly defined understanding on the part of the student of the role of elementary physics in his curriculum, and (b) the relative agreement of student, academic adviser and physics instructor as to the role of physics in the undergraduate program. Should relationships of this type be found in the experimental sample, the results can reasonably be extended to all Physics 1114 students at Oklahoma State University and, most probably, to students enrolled in the subsequent Physics 1214 course. This represents a total student enrollment in excess of 1000 students per year.

The results of the investigation may reasonably be expected to shed some light on such problems as student drop-out and failure, the relative success or lack of success of some individuals as teachers, the need for specific formulation and communication of the objectives of a course of instruction, and the need or feasibility of multiple sectioning of Physics 1114 on the basis of student interests or major field of study. To a limited extent the study may even serve as a test of the validity of the rationale which underlies the requirement of physics in the curriculum. It is hoped that this study will form the foothold for a more

inclusive study in the area of learning outcome specification for elementary physics courses.

Limitations of the Study

The results of this research may be generalized, but are basically products of those students enrolled in Physics 1114, sections 2, 4, 5, and 6, during the Spring semester of 1975 at Oklahoma State University. Any application of the conclusions drawn from the study to other populations should be interpreted with care.

There is no attempt to evaluate the effectiveness of either the Physics instructors of the lecture sections or the instructors directing the laboratory sections.

In the study, the "concept of the role of physics" is identified by the individual student's, instructor's or academic adviser's response to a thirty-item inventory as described more completely in Chapter III. Such factors as grade-point average, withdrawal rate, failure rate, and percent of students receiving satisfactory grades are used as indicators of "student success" in elementary physics. This is a crude and not altogether satisfactory criterion of success because it ignores the intangible benefits which derive to the student--benefits which are not necessarily revealed in course examinations and grades. Nevertheless, until course objectives are specifically written to include such values and evaluation techniques are developed for assaying them, we must continue with the more limited interpretation of success or accomplishment.

Clarification of Terms

Each of the following words or phrases has a specific meaning in

this study--a meaning which may or may not be in accord with the more common usage of the term.

A Topic Inventory: This refers to an instrument developed to collect information about the "concept of the role of physics in the curriculum" as seen by students, instructors and academic advisers. The instrument consists of thirty items. Each item requires the respondent to choose between two suggested topics the one which is the more appropriate for inclusion in the elementary physics course. The Topic Inventory is attached to this thesis as Appendix B.

The Concept of the Role of Physics: This refers to a perception, expectation or understanding on the part of the student or other individual as to the role to be played by elementary physics in the undergraduate curriculum. In this study, three broad conceptualizations of physics are utilized; they are: (a) physics as a "tool course" presenting factual information needed by the student in subsequent courses; (b) physics as a true liberal arts discipline concerned with the codification of physical law--a course akin to the study of natural philosophy; and (c) physics as a preparation for living in a technological world of ever-increasing complexity. The "concept of the role of physics" for an individual is defined by means of the Topic Inventory as described in Chapter III.

TC Student/TC Group: A student or group of students who conceive the elementary physics course as a tool course.

LA Student/LA Group: A student or group of students who conceive the elementary physics course as a true liberal arts course.

PL Student/PL Group: A student or group of students who imagine the elementary physics course to be a preparation for life in a tech-

nological society.

UC Student/UC Group: A student or group of students whose response(s) to the Topic Inventory indicate(s) a complete absence of affiliation with one of the three groups above.

GPA; Grade Point Average: This is an index of academic achievement. In the case of the students at Oklahoma State University, it refers to a four-point scale: A = 4.0; B = 3.0; C = 2.0; D = 1.0; F or W = 0.0.

Achievement: This is the letter grade received by the student in the elementary physics course.

Satisfactory Grade: For the purpose of this study, the grades of A, B, and C are defined as satisfactory grades.

Unsatisfactory Grade: The grades of D, F and W are defined as unsatisfactory grades.

Withdrawn (W): The grade of W is assigned to a student who terminates his or her enrollment within the semester.

Laboratory Incomplete (I): This refers to the student who does not meet the minimum requirements of the laboratory part of physics but otherwise completes the course.

Elementary Physics Course: Unless otherwise specified, this refers to the Physics 1114 course as offered at Oklahoma State University.

Basic Assumptions

It is assumed, in initial justification of the study, that the experimental sections of Physics 1114 are representative of other sections and hence conclusions of the study are equally applicable to other students in both current and future semesters.

It is taken for granted that students, asked to respond to the Topic Inventory, will do so both honestly and intelligently. Further, it is assumed that the different classifications resulting from the students' responses represent real and meaningful differences in their expectations and conceptualizations of the course they are undertaking.

The Topic Inventory asks that students check or identify areas of study that would be "most beneficial or appropriate for you". It is a basic assumption of this study that a strong parallel exists between what a student expects to find in a particular course and what he believes would be most beneficial to him.

Finally, it is assumed that such factors as grade point average, percent of students receiving satisfactory grades, and relative frequency of incomplete or withdrawal grades are valid, if limited, measures of academic success.

Organization of the Study

Chapter I has presented an introduction to the investigation to be undertaken. It includes a brief background statement for the study, a discussion of the significance and limitations of the study, a clarification of some technical terms employed and an identification of certain basic assumptions underlying the study.

Chapter II provides a review of selected literature pertinent to the study.

The design and methodology of the study, including a description of the research instruments, methods of data collection, and the statistical analysis employed, are covered in Chapter III.

Chapter IV presents the formal statement of the research hypotheses, the statistical analysis of the data, and the results of the study. Following in Chapter V is a brief summary of the study together with conclusions drawn from the study and recommendations for future investigation.

CHAPTER II

REVIEW OF SELECTED LITERATURE

Introduction

The elementary physics course provides a basic introduction to the subject matter of physics for students majoring in various disciplines. A majority of students enrolled in this course are present because of some type of requirement; either as a specific prerequisite to other courses in which the student expects to enroll, a broad general education requirement, or a more narrow major-field requirement.

Since the purpose of this study is to investigate whether or not the success of students in elementary physics is related to the presence or absence of a well-defined conceptualization, by the student, of the role of physics in the curriculum or to the relative agreement between student, instructor and academic adviser as to the role of physics in the undergraduate program, it seems appropriate to include in the review of the literature information concerning: (a) the status of the elementary physics course in American Colleges and Universities, (b) the role of physics in undergraduate curricula and (c) factors influencing students' success in the study of physics.

The Status of the Elementary Physics Course

In today's technical world almost every contribution to human living owes its development, at least in part, to the science of physics. So

the elementary course in physics with a good introduction to the idea, concept, and method of science should be an essential feature of the education of every college student, regardless of their future career objectives.

In order to accommodate students with differing professional objectives and with a wide range of mathematics background, many kinds of courses have evolved under the general title "Introductory Physics".

Boercker (8) reported a survey conducted by the American Institute of Physics in 1962-63 of the enrollments in introductory physics courses during the academic year 1961-62. Enrollments were reported by type of institution as follows: The institutions which grant doctor's degrees in physics enrolled 82,000 first-semester and first-quarter students. Master's degree institutions enrolled 28,000 and bachelor's degree institutions 42,000. In addition, 38,000 students were enrolled in elementary physics in institutions which do not grant degrees in physics. The survey also showed that over one-third of the introductory physics enrollment was in courses designed for physics majors and engineers. Students not specifically required to take physics are not enrolling in significant numbers. Boercker concluded in his report that the introductory college physics course is fulfilling a preprofessional function, but is failing its general education function.

Extensive data are collected and reported regularly concerning the numbers of undergraduate and graduate physics majors in American colleges and universities. The absolute numbers of such students increased regularly from 1950 through 1965, although the number expressed as a percent of college enrollments dropped slightly. Beginning about 1967, an economic recession and a cutback in physics-related job opportunities

led to a decrease in the number of students majoring in physics at the undergraduate level. In addition to these lost job opportunities, Ellis (12) associates the dropping enrollments with an increased student interest in social problems, mathematics difficulties, and poor college physics teaching. This trend toward a decreasing number of physics major enrollments appears to have continued through 1972.

The same factors which led to a decrease in the number of physics majors also apply to engineering students, and the number of enrollments in engineering physics courses dropped drastically between 1967 and 1972. However, at the same time there was a growth in two and four year technology programs (5) and in the social sciences. These disciplines contribute significantly to the non-calculus level beginning physics course enrollments. As a result, the total enrollment in elementary physics (both calculus and non-calculus levels) has been fairly stable. At the present time approximately 5 percent of all students at Oklahoma State University are enrolled in an elementary physics course each semester. This is probably representative of most large state universities.

The Role of Physics in Undergraduate Curricula

Physics in General Education

Rogers (40, p. 4) writing about the essential nature of physics in general education programs says:

I am thinking about our young people at a later age, not when they are learning physics, but ten or twenty years later when they are out in the world doing other work than science. They will have to work with scientists, employ scientists, make decisions about scientists, talk to their children about science, and they will live in an intellectual environment where science plays a very important philosophical part. Ten years after school or university, non-scientists will not re-

member the facts of physics clearly; but if they understood science they will retain some sympathetic understanding. And they will be able to read more science on their own--.

In general education, we need not start the training of professional scientists (that can be done much faster once the vocation is chosen); we need not try to equip everyone with a lot of scientific knowledge (that can be stored in books or left to the professionals); but we do need to give an understanding of science and its contributions to the intellectual, spiritual, and physical aspects of our lives (39).

The introductory physics course is not as popular for the non-science student as other introductory science courses. A large number of college students shy away from taking physics simply because other students have told them what a "hard course" it is. In addition many physics instructors put almost all their efforts into teaching the small minority of students who major in physics or a related science. As we can see from the statement of Conant (10, p. 1):

The present college courses in physics, chemistry, and biology by necessity are arranged primarily as a foundation for more advanced work. Therefore, they do not fulfill the function of providing for the non-scientific student an adequate introduction to the methods by which knowledge has been advanced in modern times. Such courses fail to meet the educational requirements for the non-scientific student both because they require too much detail as a basis for subsequent scientific courses; and also for another reason closely related to the complexities of our modern industrial society. Those who give such courses; and I am referring in particular to physics and chemistry, feel that they must cover those branches of the sciences which are concerned with everyday applications and also must refer to the most recent discoveries. As a result a rather superficial treatment of many phases of physics and chemistry cannot be avoided.

Rabinowitch (37, p. 23) calls for wider teaching of physics, chemistry, and biology on all levels, but above all, for integration into general education. He issues the challenge:

The central problem of higher education is how to bring up new generations, fit to live as individuals and as citizens. The changing habitat which science is creating for them involves not only education in science, but perhaps even more importantly, education about science--the development of understanding of what science is about, what it can (and what it cannot) do; appreciation of the role of science in past history and its likely role in the future; of how its revolutionary force can be best used in the framework of a stable democratic society and how this society can be adapted to the rapid changes in style, circumstances, accomplishment, and dangers of life as science changes and shapes it.

In the same point of view, Stewart (45, p. 132) recommends to physics instructors that:

It is time for those of us teaching physics to undergraduates to reconsider what we are about. In our teaching are we guided primarily by what is professionally rewarding, or are we considering what needs to be done and doing it? What most needs to be done, it seems to me, is to develop in a majority of undergraduates an understanding of our science, its central concepts and characteristic processes, its revolutionary impact and the satisfactions it affords its pursuers.

Strassenburg (46, p. 39) gave a strong argument for two separate introductory science courses, one for non-science majors and the other for those whose majors are in the sciences.

the general education students of science should not be mixed in the classroom with students who do plan to apply their scientific training to their specific goal of becoming scientists.--The two groups of students have had entirely different experiences from early ages onward. One group has tinkered with mechanical gadgets and been intrigued by mathematical puzzles. The other has found more satisfaction studying literature or the fine arts, or trying to understand the social relationships among human beings. I do not see how at the college level one can adequately serve the needs of both groups in a common course.

In those colleges and universities with a strong program of general education, physics is frequently combined with chemistry and earth science and offered as a physical science course. A good reason for combining courses in elementary science was given by Rogers (39, p. 17):

The choice between several sciences and a single one is not so severe as it sounds. Comparing two actual single-science courses, one in chemistry and the other in physics, I find at least 30 percent of the topics are common to both. And the physics course extends into astronomy as well as chemistry till it is hardly distinguishable from a 'physical science--'.

Elliott (11, p. 1) has conducted many studies about physics education. One was concerned with the attitudes and perceptions of students toward physics. He says about the essential role of physics in preparation for life:

When so many young people avoid physics courses while ostensibly preparing themselves for living in a world whose very survival depends upon sound decisions about scientific problems, it is time to closely examine the attitude and perceptions students hold of physics.

Elliott used all students enrolled in all sections of a three-quarter sequenced, introductory general physics course offered at California State Polytechnic College, San Luis Obispo, during the Winter Quarter, 1971 as the sample for his study. He concluded that physics courses attracted few women, and were not as well-liked as mathematics. Physics and mathematics have about the same difficulty but twice as many students enrolled in mathematics as enrolled in physics.

Physics in Pre-professional Education

Physics is a requirement for admission to many American professional schools such as medical school, dental schools and veterinary schools. This is due in part to the fact that elementary physics is a basic course without which the student cannot succeed in some of those professional curricula. For example, optics is necessary for the optometrist and a knowledge of the advantages and disadvantages of X-rays is very important to the medical doctor, veterinarian or dentist. In addition, there are

many studies indicating that success of students in elementary physics is a valid predictor of the later success of those students in the professional schools.

Layton (28) and Luther (31) studied the prediction of students' achievement in the first year of the College of Veterinary Medicine. They found that the physics or physical science grades the students received in the pre-veterinary program were one of the best predictors of students' achievement in veterinary medicine.

Luther (30) made another study in 1966 concerning the relationship between courses in physics, chemistry, botany, zoology, and English taken in the pre-veterinary program and the grade point average at certain junctures in the veterinary medical program. One hundred sixteen students who were meeting acceptable standards of academic performance in the professional curriculum of the College of Veterinary Medicine in the school year 1962-63 at Oklahoma State University were utilized in the study. She found that the relationships for the science courses with the various criteria were positive and moderate. She noted that the requirement to do well in physics seemed to be critical for performance at all levels in veterinary medicine.

Physics in Engineering and Technology Curricula

Physics and engineering have undergone revolutionary changes during the past century both in their individual development and in their interaction one with the other. The early physicist worked with relatively simple equipment and with concepts based primarily upon his mechanical experience. As a rule he worked with no or few assistants in a small laboratory or at a desk. But the early engineer practiced his profession

of building roads, bridges, buildings, on the basis of empirical knowledge and experience, passed down from generation to generation. The physicist in his quest for knowledge often may confine his study to one problem at a time, but the engineer must solve all problems in one integrated design synthesized from his knowledge of many disciplines. Therefore, the engineer needs a broad understanding of the fundamentals of physics and other sciences whether they have immediate application or not. He must be able to grasp the implication of new discoveries and the developing concepts of nature and be able to respond to the enthusiasm and stimulation of the creative scientist. According to the report of a Committee of the American Institute of Physics (41, p. 12):

The role of physics in engineering education is not a static one. It must respond and evolve with the momentous changes in both engineering and physics which are occurring continually. The predominant reliance of early engineering upon art is giving way to a modern technology based squarely upon the physical sciences. Since the beginning of this century we have seen as much progress in physics as had been obtained in the whole previous history of mankind. Yet the obvious and enormous increase in subject matter of modern physics is not the most significant factor relating to the aim of instruction in physics in the education of engineers. On the contrary, the cardinal aim should be that of imparting to the student a point of view, an attitude of mind, and a capacity to deal with the principles and methods of analysis of contemporary physics, for, without training and experience in these modes of thought, neither physicist nor engineer will prove competent to deal with the emerging problems of science and technology.

The American Institute of Physics report also recommends the ways of improving the role of physics in engineering education as follows:

- (1) Early contact of engineering undergraduate with physics,
- (2) Increased participation of research-minded professors in undergraduate teaching,
- (3) Introduction of more challenging experiments in laboratory instruction, and

- (4) Greater emphasis, particularly in textbooks of general physics, on ideas, principles, and methods.

The same report further demonstrated that the time devoted to physics in the engineering curriculum varies within wide margins. In several strong institutions, two years are devoted to a general physics course amounting to as much as 17 to 20 semester hours. In many cases the time assigned to physics has been substantially increased over the past decade and there is an apparent trend in this direction. Nevertheless, the program of physics most commonly found in engineering colleges is a course of 8, 10, or 12 semester hours.

Physics serves as a required and supporting course for the engineering major. Several educators have used grade point average in general physics courses to predict students' success in the engineering program. Siemens (44) tried to forecast the academic achievement of engineering students of the University of California. As part of his study, he used a regression analysis to predict the upper division grade point average based on average grade in college physics, average grade in college chemistry, average grade in college mathematics, and lower division overall grade point average. He obtained a value of 0.8 for the multiple-R.

The importance of physics as a foundation for technology is well established. According to Juszli (25), physics as the basic science serves three important roles in engineering technology programs. The first role is to provide a background of fundamental information concerning concepts, laws, principles, and terminology. The second role of physics is to provide quantitative considerations. Physics courses tend to formulate principles and to manipulate quantities which are amenable to measurements in the laboratory. The third role of physics is to pro-

vide services to the bread-and-butter concerns of the technician which emphasizes engineering application. This involves teaching a responsible approach to equipment; it also involves teaching responsible experimental investigations, methods of measurement, analysis of problems, and evaluation of results.

Harris (18, p. 5) believes that physics courses serve as the common intellectual meeting ground of engineers and technicians. He writes:

Technicians who work in supporting roles to engineers and scientists, and those engaged in industrial design, production, and testing operations, need a significant background in physics and mathematics in addition to specialized knowledge and skill. The engineering technicians, in particular, should have both breadth and depth in these basic disciplines.

Factors Influencing Students' Success in Physics

The factors influencing students' achievement in college may be classified as: (a) intellective factors (measures of IQ, aptitude, and prior achievement), and (b) non-intellective factors (measures of personality, motivation, attitude, and conception). Research specifically designed to identify those factors significantly related to the academic success of physics students has been limited in the past, but with an increasing societal demand, an increase in such studies is noted. Several studies concerned with the intellective factors influencing students' achievement in college physics have been reported. Very few studies have been conducted to determine the non-intellective factors which influence success in college physics.

Foster (14) studied students in survey courses in physical science in 1938 at State Teacher College, Kearney, Nebraska. From the accumulated data of all students enrolled in college physics and college chemistry for a period of five years, he concluded that intelligence is the

most important factor tending toward success in college physics. The influence of high school physics on success in college physics has some significance, but the influence of high school mathematics seemed negligible.

It appears that the students' intelligence and their achievement are closely related in most fields of study. This is confirmed by the studies of Mallinson (33), and Garrett (15).

Mallinson (33) investigated factors influencing achievement in science at the college level of 1,191 students who graduated from 12 mid-western high schools in 1963. Factors investigated included interest, intelligence, high school achievement, and family background. Data sources used in the study included secondary school standardized tests, college transcripts, Kuder Preference Records completed during freshman and junior college years, and a questionnaire completed during sophomore and junior years. Mallinson completed his study in 1969 and reported that student IQ and the belief that the parents thought education important, related most significantly to college achievement in science. There was a definite relationship between success in college science and a student's interest in high school science. The size of the high school or college from which a student came did not seem to be related to the student's success.

Garrett (15) reviewed studies about factors related to scholastic success in colleges of arts and sciences and teachers colleges in 1949. Among several studies he found that students with high intelligence tend to succeed in college in spite of all other factors operating.

A number of studies of the high school background of college students in physics were investigated. One of the more extensive studies

was reported by Adams and Garrett (1) in 1954 in which a study was made of 877 beginning physics students at Louisiana State University. They found that articulation between college physics and various types of high school work was poor but that high school records were better predictors of success in college physics than entrance examination scores. While no positive correlation was found between high school physics and success in college physics it was indicated that high school physics does not hinder the student of college physics. In addition, a relatively high relationship appeared to exist between achievement in college physics and achievement in first year college mathematics.

Woodward (49) made a study investigating the articulation between a first course in college physics and certain factors in the high school and college background of a group of 156 students in the fall of 1956 at Oklahoma State University. Among those sampled only 53 students, or 33.97 percent, had taken a course in high school physics. He reported that those students who had taken high school physics had a slightly higher mean grade in a first course in college physics than those who had not taken high school physics. He further reported that those students who had taken physics in high school had a slightly higher mean grade in all high school work than those who had not. In addition, the correlation between most phases of the high school work of the sample and college physics was relatively low.

Kruglak and Keller (27) investigated the prognostic value of various factors with respect to achievement in college physics. The records of 343 students enrolled in the general physics course sequence at the Institute of Technology, University of Minnesota during 1946-47 furnished the basic data for the study. The achievement criteria were the final

grade in the three quarters of physics and the scores on the several Co-operative Physics Tests. As the results, grades for the final quarter of this study gave the high Pearson coefficients of correlation with freshman total honor point ratios, $r = .57$; with freshman mathematics point-hour ratios, $r = .51$. The correlation coefficient between the final quarter of the physics sequence and high school rank was only .17.

Bolte (9) used multiple correlation techniques to analyze success in college physics and the high school backgrounds of students who had completed the first semester in college physics at the State University of Iowa. The results of his study indicated that high school physics was an asset in the first course in college physics. In addition, the high school physics grade has predictive value in determining a student's probable success in college physics. High school background in mathematics, however, appears to have no predictive value in determining success in college physics. This is in contrast to the study of Stuit and Lapp (47) that mathematics ability appeared to be more closely related than any other factor to achievement in college physics.

Schroeder and Sledge (42) studied the non-intellective factors related to academic success. They pointed out that intellective factors were found to be more predictive of college achievement than the non-intellective factors. They further indicated that interest and motivation are overwhelmingly positive in their relationship to achievement, but personal and social adjustment have both positive and negative correlation with the academic success.

The student's personal data such as race, religion, and his parents' educational and economic status have only very small effects on his

academic achievement during the freshman year in college as indicated by
Astin (3).

CHAPTER III

RESEARCH DESIGN AND METHODOLOGY

Introduction

The first objective of this study is the development of an instrument for the purpose of identifying the role of elementary physics in the undergraduate curriculum as seen by entering physics students, their instructors and their academic advisers. Secondly, the investigation attempts to determine whether or not the success of students in elementary physics is related to their conceptualization of the role of physics in the curriculum or to the presence or absence of a common understanding of the role of physics shared between the student and his instructor.

The study was conducted in the Spring Semester of the 1974-75 academic year at Oklahoma State University and involved some 200 students enrolled in the first semester general physics course. This chapter presents (a) a discussion of the development and validation of the research instrument; (b) the measures of student success adopted for the study and (c) the procedures followed in administering the research instrument, scoring student responses and analyzing the data.

Development of the Research Instrument

This study begins with the assumption that many, if not all, students entering the elementary physics course have an established concept of the role of the course in their curriculum. They have a set of under-

standings or expectations as to why they are in the course, what the course will be like, and what it will do for them. It is desirable to know whether these understandings are consistent with those held by their instructors and those held by academic advisers who represent the academic departments of the students' majors. It is these departmental requirements that ultimately account for many enrollments in college physics classes.

A preliminary reading of the literature identifies three motivations for students, either as individuals or in response to departmental requirements, to undertake the study of elementary physics. Specifically, the elementary physics course may be seen as (a) a "tool" course presenting factual information without which the student cannot expect to succeed in subsequent courses; (b) a true liberal arts discipline concerned with the codification and explanation of physical law--a course akin to the study of natural philosophy; or (c) a preparation for living in a technological world of ever increasing complexity. These three broad conceptual models were chosen as the framework for the study and the Topic Inventory which was used in forming the experimental groups.

It is obvious that elementary physics courses designed to represent these three interpretations of the role of physics in the undergraduate curriculum can be very different. This is not to say, however, that one well designed course cannot serve all three missions to some extent.

The initial step in the development of a Topic Inventory or questionnaire to identify how the student, or other individual, views the role of elementary physics was to gather together numerous elementary physics textbooks written by authors with one or the other of these viewpoints specifically in mind. Modern Technical Physics by Beiser (6)

or Physics for Biology and Pre-Med Students by Greenberg (17) are typical of texts which view elementary physics as a "tool" course in the best sense of that phrase. Physics: The Fabric of Reality by Kim (26) or the classic Physics for the Inquiring Mind by Rogers (38) are excellent presentations of physics as "natural philosophy". Texts which convey a concern for the need to have an educated populace prepared for living with and understanding our technological surroundings include Problems of Our Physical Environment by Priest (36) and Physics, Energy and Our World by Highsmith (20). For convenience, these course types and the conceptual structures on which they rest will be referred to in the future as TC (tool courses), LA (liberal arts courses) and PL (preparation for living in a technical world courses).

With the aid of such sources as these, ten topics representative of the subject matter appropriate for inclusion in an elementary physics course of each conceptual bent were selected. Each was formulated as a short statement, depersonalized, and as free as possible of coloring or technical terminology. The thirty topics together with the type of course with which they were associated are listed in Appendix A.

These thirty topics were next randomly combined to form a series of 30 pairs of topics in which the student or other respondent is to indicate a preference between two topics representing two differing course concepts. Each of the original topics is used twice so that the student must make 10 choices between TC and LA topics, 10 choices between TC and PL topics, and 10 choices between LA and PL topics. These 30 sets of paired topics comprise the Topic Inventory, the basic research instrument employed in the research.

Validation of the Research Instrument

Due to the time limitations imposed on the study no formal validation of the research instrument was attempted. However, it was believed essential to verify the investigator's faith in the various items of the inventory and attempt to demonstrate that they adequately reflected the different viewpoints labeled TC, LA, and PL above. This was accomplished by requesting fifteen instructors of college-level physics to respond to the Topic Inventory. The instructors were chosen because of their known interest and experience in the teaching of college level physics.

Five of the instructors were asked to:

"--imagine that you are preparing to teach a non-majors course which looks at physics as 'a tool course designed primarily to teach factual information without which the student cannot expect to succeed in subsequent courses in other disciplines.'

Keeping this orientation in mind, please check the one topic in each of the 30 items which you consider to be the more appropriate for inclusion in the course."

Five others were instructed to:

"--imagine that you are preparing to teach a non-majors course which considers physics as 'a true liberal arts discipline concerned with the codification and explanation of physical law--a course akin to the study of natural philosophy.'"

The remaining five were requested to:

"--imagine that you are preparing to teach a non-majors course in which 'the primary general studies objective is that of preparing individuals for life in a technological world of ever increasing complexity.'"

A sample of the covering letter used in contacting the panel of instructors is included as Appendix C.

Fourteen of the fifteen instructors responded and their inventories were analyzed in the same manner as those returned by the students; see

the section on research procedures which follows at the end of this chapter. Of the five instructors who were asked to select topics most appropriate for use in a "tool" course, three met the test of choosing only those topics which had previously been identified as representative of students with that particular understanding of the role of physics. A fourth instructor regularly selected "tool" topics over PL topics but included a significant number of LA topics among his choices. The fifth instructor also showed a mixed response in the choices selected.

Of the five instructors asked to identify topics which would most adequately prepare students for life in a technological world, four selected only the previously identified PL topics. The fifth selected PL topics in strong preference to LA topics but did include a significant proportion of the TC topics.

Finally, the four instructors asked to identify the more appropriate liberal arts (LA) topics gave a more varied response. Two clearly selected the pre-determined LA responses but the other two tended to choose the PL choices. In summary, ten of the fourteen instructors from other universities had responses which were appropriate to the classification they were asked to check. That is, they identified as the more appropriate topics for inclusion in an elementary course those topics which had previously been selected as representative of students with a particular concept or understanding of the role of elementary physics in the curriculum. It is felt that these responses constitute a credible, if limited, validation of the topic classification used in the study.

Measurement of Student Achievement

Any successful educational endeavor will surely have many desirable

effects other than the acquisition of factual knowledge as measured by conventional examinations. Among these outcomes can be listed improved intellectual skills, appreciation of the cultural contributions of the discipline, and an integration of the various aspects of a formal education into a whole person. In this study, however, student success is defined in the more narrow sense. Thus, the course grade is used as a measure of achievement for the individual student. Such combinations as average grade-point, percent of students receiving satisfactory grades, or percent of students receiving grades of W, F, or I are taken as measures of the relative success, or lack of success, of the different experimental groups.

Research Procedures

Administration of the Topic Inventory

The Topic Inventory was administered to 212 students enrolled in sections 2, 4, 5, and 6 of Physics 1114, the first half of the General Physics 1114-1214 sequence, during the Spring Semester of the 1974-75 academic year. After a brief word of explanation as to the goals of the research and the nature of the questionnaire, the students were asked to check the Topic Inventory. Attention was called to the words "beneficial" and "appropriate" appearing in the instructions. Students were also asked to furnish biographical data which included name, college of enrollment, major field of study, and college class. Students were told that they could, if they wished, decline to participate in the study. None elected to do so.

The Topic Inventory was also checked by each of the two instructors teaching the lecture sections and 13 academic advisers chosen from the

fields of agriculture, technology and life sciences. These disciplines send significant numbers of students to the Physics 1114 course. The academic advisers were asked to respond on the basis of which of the two topics in each pair would be more appropriate for students majoring in their discipline. A list of the academic advisers who participated is included as Appendix F and the covering letter requesting their assistance is reproduced as Appendix E.

Scoring of Inventories; Classification of Students

The completed questionnaires were hand scored by the author and associates. Students completing the questionnaire were faced with 30 choices between two topics representing differing concepts of the role of physics in the undergraduate curriculum. In 10 inventory items the choice was between TC topics and LA topics; 10 represented TC versus PL topics; the remaining 10 were choices between LA and PL topics. The decision was made, rather arbitrarily, to classify a student as a "TC student" if he indicated a preference for TC topics over LA topics 7 or more times out of the 10 choices and if he elected TC topics over PL topics on 7 or more occasions out of the 10 opportunities. Similar criteria were imposed in the classification of "LA students" and "PL students."

A fourth experimental group, referred to in this study as the UC group, is composed of all those students who elected each possible choice (such as TC over LA, LA over TC, TC over PL, etc.) at least 4 times but no more than 6 times. It was believed that this group of students might most accurately represent a significant proportion of students who enter the elementary physics course without any prior con-

ception as to the nature, content or possible contribution of the course. The distribution of students among the various experimental groups is discussed further in the next chapter.

The χ^2 -Test

Responses to the questionnaire "Physics 1114--A Topic Inventory" were hand checked and scored by the author and associates as described in the previous section. In order to test whether or not the success of students in elementary physics is related to the way in which they perceive the role of the course in their curriculum and the presence or absence of an accord between student and instructor as to the role of elementary physics in the curriculum, the chi-square test was the statistical technique employed. More powerful statistical techniques involving multiple correlation methods were not adopted because such variables as age of student, academic background, and mathematical skills were not measured or controlled in the study. Variables of this type are known to affect the success rates of students in elementary physics.

Chi-square contrasts the difference between observed or obtained results with those results theoretically expected. This technique uses ordinal or nominal level of measurement and is nonparametric.

The following formulas for computation of the chi-square were employed (13,16,43).

$$\chi^2 = \frac{N(AD - BC)^2}{(A + B)(C + D)(A + C)(B + D)} \quad (3.1)$$

where

χ^2 = value of chi-square in a fourfold contingency table

N = total number of cases

A = observed number of cases categorized in 1st row of 1st column

B = observed number of cases categorized in 1st row of 2nd column

C = observed number of cases categorized in 2nd row of 1st column

D = observed number of cases categorized in 2nd row of 2nd column

When the entries in a fourfold contingency table are quite small, Yates' correction for continuity should be applied to formula (3.1).

The corrected formula reads:

$$\chi^2 = \frac{N(|AD - BC| - N/2)^2}{(A + B)(C + D)(A + C)(B + D)} \quad (3.2)$$

where

χ^2 = value of chi-square for 2 x 2 table, corrected for continuity

The chi-square for k independent samples may be tested by applying the following formula

$$\chi^2 = \sum_{i=1}^r \sum_{j=1}^k \frac{(O_{ij} - E_{ij})^2}{E_{ij}} \quad (3.3)$$

where

χ^2 = value of chi-square for k independent samples

O_{ij} = observed number of cases categorized in i^{th} row of j^{th} column

E_{ij} = number of cases expected under H_0 to be categorized in i^{th} row of j^{th} column

$\sum_{i=1}^r \sum_{j=1}^k$ directs one to sum over all cells

The values of χ^2 yielded by formulas (3.1, 3.2 and 3.3) are distributed approximately as chi-square with degrees of freedom, df , = $(r-1) \times$

$(k-1)$, where r = the number of rows and k = the number of columns in the contingency table.

A .05 level of significance was established and utilized as a basis for rejecting or not rejecting a null hypothesis in this study. The detailed analysis of the data is given in Chapter IV.

CHAPTER IV

ANALYSIS OF DATA AND RESULTS OF STUDY

Introduction

The research instrument used in this study, "Physics 1114--A Topic Inventory" was administered to two hundred twelve students enrolled in Physics 1114 and their instructors. Thirteen academic advisers of undergraduate students in various colleges of the Oklahoma State University and fourteen physics instructors at colleges and universities other than Oklahoma State University also checked the questionnaire.

This chapter presents the data which resulted from the use of the instrument together with both qualitative and statistical analyses as appropriate. To insure clarity, a common format is used in the analysis of each experimental hypothesis. This consists of a restatement of the hypothesis, a supporting data table or chi-square calculation as appropriate and a summary of the experimental observations.

Statement of the Experimental Hypotheses

The hypotheses that guide this study, stated in the null form, are as follows:

Hypothesis H_1 : There are no significant differences between the way (a) academic advisers, (b) students of elementary physics, and (c) instructors of elementary physics identify the

role of elementary physics in the undergraduate curriculum.

$H_{1.1}$: There are no significant differences between the way academic advisers and students of elementary physics identify the role of elementary physics in the undergraduate curriculum.

$H_{1.2}$: There are no significant differences between the way students of elementary physics and instructors of elementary physics identify the role of physics in the undergraduate curriculum.

$H_{1.3}$: There are no significant differences between the way instructors of elementary physics and academic advisers view the role of physics in the undergraduate curriculum.

Hypothesis H_2 : There are no significant differences in the success rates in elementary physics of students with clearly defined conceptions of the role of physics in the undergraduate curriculum and students without such well-defined conceptions.

$H_{2.1}$: There are no significant differences in the grade distributions in elementary physics of students with clearly defined conceptions of the role of physics in the undergraduate curriculum and students without such conceptions.

H_{2.2}: There are no significant differences between the numbers of students receiving satisfactory and unsatisfactory grades in elementary physics for those with clearly defined conceptions of the role of physics in the undergraduate curriculum and those without such well-defined conceptions.

H_{2.3}: There are no significant differences between the numbers of students receiving complete and incomplete laboratory grades in elementary physics for those with well-defined conceptions of the role of physics in the undergraduate curriculum and those lacking such well-defined conceptions.

H_{2.4}: There are no significant differences between the numbers of students withdrawing from the elementary physics course for those with clearly defined conceptions of the role of the course in the curriculum and those without such conceptions.

Hypothesis H₃: There are no significant differences in the success rates in elementary physics of those students who share the instructor's conceptualization of the role of physics in the curriculum and those students who do not.

H_{3.1}: There are no significant differences in the grade distributions in elementary physics of students who share the instructor's conception of the role of physics in the undergraduate curriculum and

those who do not share the instructor's conception of the role of physics in the undergraduate curriculum.

H_{3.2}: There are no significant differences between the numbers of students receiving satisfactory and unsatisfactory grades in elementary physics for those students who share the instructor's conception of the role of physics in the undergraduate curriculum and those who do not.

H_{3.3}: There are no significant differences between the numbers of students receiving complete and incomplete laboratory grades in elementary physics for those who share the instructor's conceptualization of the role of the physics course and those who do not.

H_{3.4}: There are no significant differences between the numbers of students withdrawing from the elementary physics course for those who share the instructor's conception of the role of physics in the undergraduate curriculum and those who do not.

Analysis of the Data

Summary of Student Data

The data collected from two hundred twelve student questionnaires is summarized in Tables I, II, and III. Table I presents a distribution

TABLE I
NUMBER OF STUDENTS IN EACH CONCEPTUAL GROUP

Group	Lecture Section				Total	
	2	4	5	6	Number	Percent
TC	5	6	7	7	25	11.8
LA	1	6	3	3	13	6.1
PL	8	12	7	11	38	17.9
UC	3	8	3	8	22	10.4
All Other	26	29	28	31	114	53.8
Total	43	61	48	60	212	100.0

TABLE II
GRADE DISTRIBUTIONS OF STUDENTS IN EACH CONCEPTUAL GROUP

Group	Grade Distributions											
	A		B		C		D		F		W	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
TC	9	36.0	4	16.0	6	24.0	2	8.0	2	8.0	2	8.0
LA	0	0.0	5	38.5	6	46.1	1	7.7	0	0.0	1	7.7
PL	5	13.2	6	15.8	11	28.9	10	26.3	1	2.6	5	13.2
UC	3	13.7	5	22.7	5	22.7	4	18.2	0	0.0	5	22.7
All Other	14	12.3	22	19.3	30	26.3	13	11.4	5	4.4	30	26.3
Total	31	14.6	42	19.8	58	27.4	30	14.1	8	3.8	43	20.3

TABLE III
INCOMPLETE AND WITHDRAW GRADES IN EACH CONCEPTUAL GROUP

Group	Incomplete Grade		Withdraw Grade	
	Number	Percent	Number	Percent
TC	3	12.0	2	8.0
LA	3	23.1	1	7.7
PL	4	10.5	5	13.2
UC	1	4.6	5	22.7
All Other	12	10.5	30	26.3
Total	23	10.9	43	20.3

of students among the various conceptual groupings for each lecture section. The classification is carried out as described in Chapter III. Table II contains grade distributions at the end of the semester for each of the four experimental groups, for "all other students" and for the entire student population. No "incomplete" grades are shown in Table II. Rather, for the purposes of this study, the distribution shows the grades received by these students upon removal of the incomplete grades. Finally, Table III presents the number of students receiving incomplete grades at the end of semester and the number of students who withdrew from the course prior to the end of the semester. Where meaningful, the information is also repeated in the form of a percent. These data, together with the responses of instructors and academic advisers, constitute the raw material for the study.

Summary of Instructors' Responses

Two instructors were involved in teaching the four lecture sections used in the study. When their completed questionnaires were checked using the same criteria as had been applied to the student questionnaires, each instructor was classified in the TC group. That is, each instructor selected a TC topic as more appropriate than a PL topic at least 7 of 10 times and each instructor selected a TC topic in preference to an LA topic on at least 7 of 10 occasions.

Summary of Academic Advisers' Responses

Thirteen academic advisers from several colleges of the university checked the questionnaire. When their responses were tabulated, eight were found to fall in the TC group, and one each in the PL and LA groups. The remaining three academic advisers have to receive a modified classification. Each selected the TC group 7 or more times over either the PL or LA group but failed to select the TC group over the remaining group.

Tests of the Experimental Hypotheses

This section presents a qualitative examination and, when appropriate, a chi-square analysis of the data collected from the students, instructors and academic advisers responses to the research instrument. Each of the formal hypotheses, or groups of nested hypotheses, is discussed in turn.

Hypothesis H_1 : There are no significant differences between the way (a) academic advisers, (b) students of elementary physics, and (c) instructors of elementary physics identify the

role of elementary physics in the undergraduate curriculum.

The data do not permit any meaningful statistical evaluation of Hypothesis H_1 or any of the three subordinate Hypotheses $H_{1.1}$ through $H_{1.3}$. The hypotheses ask, in essence, do students of Physics 1114, their instructors, and the academic advisers who represent the students' major fields see Physics 1114 in the same way? Do these three groups of individuals agree as to the objectives of the course as reflected in their choices of "most appropriate" course content?

The limited data available suggest strongly that the two instructors and a majority of academic advisers are in accord. Both instructors and 8 of 13 advisers were given a TC classification. Those individuals appear to see the primary objective of the course as one of preparing students to overcome immediate and direct problems associated with studies in their major fields. Three of the remaining five advisers have strong tendencies to agree but with some qualifications. Only one adviser sees a major liberal arts role for physics and only one adviser sees a predominant need to prepare students for "life in a technical society". The latter person is a faculty member in the school of technology.

On the other hand, Table I indicates no such accord exists between student and instructor (Hypothesis $H_{1.2}$) or student and adviser (Hypothesis $H_{1.1}$). Nearly 65 percent of the students cannot be classified in any one of the three identified conceptual groups. The implication is that these students have no clearly defined expectations of what the course will be or conceptions of what the course should be. Of those students who were classified into a definite conceptual group, two-thirds were either LA or PL in opposition to the TC classification of the in-

structors and most of the advisers. Only 12 percent of the total student population shared the TC conceptual group with their instructors.

In summary, instructors and advisers are in general agreement--they see the primary function of elementary physics to be that of presenting factual information without which the student cannot expect to succeed in subsequent courses in other fields. The vast majority of students have no well-formed concept of what the study of physics is or can be expected to be.

Hypothesis H_2 : There are no significant differences in the success rates in elementary physics of students with clearly defined conceptions of the role of physics in the undergraduate curriculum and students without such well-defined conceptions.

Hypothesis H_2 will be discussed in terms of the individual subordinate Hypotheses $H_{2.1}$ through $H_{2.4}$.

Hypothesis $H_{2.1}$: There are no significant differences in the grade distributions in elementary physics of students with clearly defined conceptions of the role of physics in the undergraduate curriculum and students without such conceptions.

Table IV presents a chi-square analysis of the grade distributions reported for all students with well-defined conceptions of the role of elementary physics versus students in the UC group. The presentation follows the general format used by Garrett (16), and Siegel (43). Following a suggestion of Siegel (43), a combined category has been formed

TABLE IV

CHI-SQUARE ANALYSIS OF GRADE DISTRIBUTIONS; STUDENTS WITH CLEARLY
DEFINED CONCEPTIONS OF THE ROLE OF ELEMENTARY PHYSICS
VERSUS STUDENTS IN UC GROUP

Group	Grade Distributions						Total
	A	B	C	D	F	W	
	<u>Combined Categories</u>				<u>Combined Categories</u>		
TC + LA + PL	29		23		24		76
UC	8		5		9		22
Total	37		28		33		98

Chi-square = 0.702 with 2 degrees of freedom.

Not significant at .95 level of confidence.

for A and B grades and another for D, F and W grades because of the small sample size in one or more cells of the chi-square array. This procedure will be repeated as necessary in later tables.

In Table V, the analysis is repeated but the comparison is between students classified in the TC plus LA plus PL groups and all other students in the Physics 1114 classes. For Table IV a chi-square of 0.702 is calculated and for Table V a chi-square of 7.847 is obtained. Neither of these values is significant at the .95 level of confidence and Hypothesis $H_{2.1}$ cannot be rejected.

Hypothesis $H_{2.2}$: There are no significant differences between the numbers of students receiving satisfactory and unsatisfactory grades in elementary physics for those with clearly defined conceptions of the role of physics in the undergraduate curriculum and those without such well-defined conceptions.

A casual reading of Tables I, II and III indicate several areas of possible interest. Thus, we note that only 10 percent of students in the TC, LA, or PL groups withdrew from Physics 1114 before the end of the semester as opposed to about 26 percent of the remaining students. Also, 36 percent of the students in the TC group received an A grade while none of the LA students received an A grade.

Table VI contains five separate two-fold chi-square analyses of the numbers of satisfactory grades (A, B and C) versus unsatisfactory grades (D, F and W) received by students in the various conceptual groups. None of the chi-square values resulting are significant at the .95 level of confidence and Hypothesis $H_{2.2}$ cannot be rejected.

TABLE V

CHI-SQUARE ANALYSIS OF GRADE DISTRIBUTIONS; STUDENTS WITH CLEARLY
DEFINED CONCEPTIONS OF THE ROLE OF ELEMENTARY PHYSICS
VERSUS ALL OTHER STUDENTS

Group	Grade Distributions						Total
	A	B	C	D	F	W	
TC + LA + PL	14	15	23	13	3	8	76
All But TC + LA + PL	17	27	35	17	5	35	136
Total	31	42	58	30	8	43	212

Chi-square = 7.847 with 5 degrees of freedom.

Not significant at .95 level of confidence.

TABLE VI

CHI-SQUARE ANALYSIS OF NUMBERS OF SATISFACTORY GRADES RECEIVED
BY STUDENTS IN VARIOUS CONCEPTUAL GROUPS

Group	Grade		Total	Chi-Square
	Satisfactory	Unsatisfactory		
TC + LA + PL	52	24	76	
UC	13	9	22	
Total	65	33	98	0.665
TC + LA + PL	52	24	76	
All But TC + LA + PL	79	57	136	
Total	131	81	212	2.205
TC	19	6	25	
UC	13	9	22	
Total	32	15	47	1.539
LA	11	2	13	
UC	13	9	22	
Total	24	11	35	1.428
PL	22	16	38	
UC	13	9	22	
Total	35	25	60	0.008

Degrees of freedom = 1

Hypothesis $H_{2.3}$: There are no significant differences between the numbers of students receiving complete and incomplete laboratory grades in elementary physics for those with well-defined conceptions of the role of physics in the undergraduate curriculum and those lacking such well-defined conceptions.

Physics 1114 laboratory uses an "open-laboratory" format in which students are expected to assume major responsibility for planning and executing their laboratory work. It was felt that the differences in students' interests and other characteristics might be reflected in their perseverance, dedication or concern for laboratory work. Table VII examines the relative numbers of students receiving incomplete grades as a result of failure to complete laboratory assignments. Neither of the chi-square values resulting is significant at the .95 level of confidence and Hypothesis $H_{2.3}$ cannot be rejected.

Hypothesis $H_{2.4}$: There are no significant differences between the numbers of students withdrawing from the elementary physics course for those with clearly defined conceptions of the role of the course in the curriculum and those without such conceptions.

Hypothesis $H_{2.4}$ attempts to ascertain whether or not students with well-defined conceptions of the role of physics in the undergraduate curriculum are more or less likely to withdraw from the course than other students. Table VIII examines this question in two two-fold chi-square arrays. The first examines the numbers of withdrawals observed in the

TABLE VII

CHI-SQUARE ANALYSIS OF LABORATORY INCOMPLETE GRADES: STUDENTS WITH
WELL-DEFINED CONCEPTIONS OF THE ROLE OF ELEMENTARY
PHYSICS VERSUS OTHER STUDENTS

Group	Grade		Total	Chi-square
	Complete	Incomplete		
TC + LA + PL	66	10	76	
UC	21	1	22	
Total	87	11	98	0.553
TC + LA + PL	66	10	76	
All But TC + LA + PL	123	13	136	
Total	189	23	212	0.653

Degrees of freedom = 1.

TABLE VIII

CHI-SQUARE ANALYSIS OF NUMBERS OF STUDENTS WITHDRAWING FROM
 PHYSICS 1114; STUDENTS WITH WELL-DEFINED CONCEPTIONS
 OF THE ROLE OF PHYSICS VERSUS STUDENTS
 WITHOUT SUCH CONCEPTIONS

Group	Number of Student		Total	Chi-square
	Remaining	Withdrawing		
TC + LA + PL	68	8	76	
UC	17	5	22	
Total	85	13	98	1.270
TC + LA + PL	68	8	76	
All But TC + LA + PL	101	35	136	
Total	169	43	212	6.970*

Degrees of freedom = 1.

*Significant at .95 level of confidence.

TC plus LA plus PL groups versus the UC group. A chi-square of 1.27 is computed which is not significant at the .95 level of confidence. The second array in Table VIII reports the numbers of withdrawals for all students in the same three groups versus all remaining students. The computed chi-square of 6.97 is significant and Hypothesis $H_{2.4}$ can be rejected.

Hypothesis H_3 : There are no significant differences in the success rates in elementary physics of those students who share the instructor's conceptualization of the role of physics in the curriculum and those students who do not.

Hypothesis H_3 will be examined in terms of the nested subordinate Hypotheses $H_{3.1}$ through $H_{3.4}$.

Hypothesis $H_{3.1}$: There are no significant differences in the grade distributions in elementary physics of students who share the instructor's conception of the role of physics in the undergraduate curriculum and those who do not share the instructor's conception of the role of physics in the undergraduate curriculum.

It seems reasonable that a shared understanding between instructor and student of the goals or objectives of a course should enhance the learning experience. This premise is examined in Tables IX, X, XI and XII in which the grade distributions of students in the TC group are compared with the grade distributions reported for students in other conceptual groups. The chi-square values computed from Tables IX, X and XII are not significant at the .95 level of confidence set for this

TABLE IX

CHI-SQUARE ANALYSIS OF GRADE DISTRIBUTIONS OF STUDENTS WHO SHARE
THE INSTRUCTOR'S CONCEPT OF THE ROLE OF ELEMENTARY
PHYSICS AND STUDENTS WHO DO NOT
(TC VS. PL)

Group	Grade Distributions						Total
	A	B	C	D	F	W	
					Combined Categories		
TC	9	4	6		6		25
PL	5	6	11		16		38
Total	14	10	17		22		63

Chi-square = 5.084 with 3 degrees of freedom.

Not significant at .95 level of confidence.

TABLE X

CHI-SQUARE ANALYSIS OF GRADE DISTRIBUTIONS OF STUDENTS WHO SHARE
THE INSTRUCTOR'S CONCEPT OF THE ROLE OF ELEMENTARY
PHYSICS AND STUDENTS WHO DO NOT
(TC VS. UC)

Group	Grade Distributions						Total
	A	B	C	D	F	W	
	<u>Combined Categories</u>				<u>Combined Categories</u>		
TC	13		6		6		25
UC	8		5		9		22
Total	21		11		15		47

Chi-square = 1.628 with 2 degrees of freedom.

Not significant at .95 level of confidence.

TABLE XI

CHI-SQUARE ANALYSIS OF GRADE DISTRIBUTIONS OF STUDENTS WHO SHARE
THE INSTRUCTOR'S CONCEPT OF THE ROLE OF ELEMENTARY
PHYSICS AND STUDENTS WHO DO NOT
(TC VS. LA + PL + UC)

Group	Grade Distributions						Total
	A	B	C	D	F	W	
					Combined Categories		
TC	9	4	6		6		25
LA + PL + UC	8	16	22		27		73
Total	17	20	28		33		98

Chi-square = 8.215 with 3 degrees of freedom.

Significant at .95 level of confidence.

TABLE XII

CHI-SQUARE ANALYSIS OF GRADE DISTRIBUTIONS OF STUDENTS WHO SHARE
THE INSTRUCTOR'S CONCEPT OF THE ROLE OF ELEMENTARY
PHYSICS AND STUDENTS WHO DO NOT
(TC VS. ALL BUT TC)

Group	Grade Distributions						Total
	A	B	C	D	F	W	
	<u>Combined Categories</u>				<u>Combined Categories</u>		
TC	13		6	2	4		25
All But TC	60		52	28	47		187
Total	73		58	30	51		212

Chi-square = 4.107 with 3 degrees of freedom.

Not significant at .95 level of confidence.

study. The chi-square value of 8.215 associated with Table XI is, however, significant at the .95 level of confidence and on the basis of this result Hypothesis $H_{3.1}$ is rejected. The full significance of this result is yet to be resolved.

Hypothesis $H_{3.2}$: There are no significant differences between the numbers of students receiving satisfactory and unsatisfactory grades in elementary physics for those students who share the instructor's conception of the role of physics in the undergraduate curriculum and those who do not.

Table XIII contains a series of five separate two-fold chi-square arrays representing the numbers of students receiving satisfactory versus unsatisfactory grades. The comparisons are between students in the TC group who share the instructor's conception of the role of physics in the undergraduate curriculum and various other groups of students. None of the calculated chi-square values are significant at the .95 level of confidence and Hypothesis $H_{3.2}$ cannot be rejected.

Hypothesis $H_{3.3}$: There are no significant differences between the numbers of students receiving complete and incomplete laboratory grades in elementary physics for those who share the instructor's conceptualization of the role of the physics course and those who do not.

An examination of the data presented in Table XIV fails to find any significant differences in the numbers of students receiving incomplete grades when a comparison is made between the TC group and other groups

TABLE XIII

CHI-SQUARE ANALYSIS OF NUMBERS OF SATISFACTORY GRADES RECEIVED
BY STUDENTS WHO SHARE THE INSTRUCTOR'S CONCEPTION
OF THE ROLE OF ELEMENTARY PHYSICS AND
STUDENTS WHO DO NOT

Group	Grade		Total	Chi-square
	Satisfactory	Unsatisfactory		
TC	19	6	25	
LA	11	2	13	
Total	30	8	38	0.039
TC	19	6	25	
PL	22	16	38	
Total	41	22	63	2.175
TC	19	6	25	
UC	13	9	22	
Total	32	15	47	1.539
TC	19	6	25	
LA + PL + UC	46	27	73	
Total	65	33	98	1.406
TC	19	6	25	
All But TC	112	75	187	
Total	131	81	212	2.420

Degrees of freedom = 1

TABLE XIV

CHI-SQUARE ANALYSIS OF NUMBERS OF LABORATORY INCOMPLETE GRADES
 RECEIVED BY STUDENTS WHO SHARE THE INSTRUCTOR'S CONCEPT OF
 THE ROLE OF ELEMENTARY PHYSICS
 AND STUDENTS WHO DO NOT

Group	Grade		Total	Chi-square
	Complete	Incomplete		
TC	22	3	25	
LA + PL + UC	65	8	73	
Total	87	11	98	0.051
TC	22	3	25	
All But TC	167	20	187	
Total	189	23	212	0.021

Degrees of freedom = 1.

of students. Consequently, Hypothesis $H_{3,3}$ cannot be rejected.

Hypothesis $H_{3,4}$: There are no significant differences between the numbers of students withdrawing from the elementary physics course for those who share the instructor's conception of the role of physics in the undergraduate curriculum and those who do not.

The chi-square analysis shown in Table XV reveals no significant differences between the numbers of students withdrawing from Physics 1114 for those students who share the instructor's conception of the role of elementary physics and those students who do not. Therefore, the hypothesis cannot be rejected.

Summary

Three major experimental hypotheses and eleven minor hypotheses were examined and the results summarized in this chapter. Chi-square analysis were used when appropriate. One of the major hypotheses and four of the minor hypotheses could be rejected on the basis of the experimental evidence available.

TABLE XV

CHI-SQUARE ANALYSIS OF NUMBERS OF STUDENTS WITHDRAWING FROM
 PHYSICS 1114; STUDENTS WHO SHARE THE INSTRUCTOR'S
 CONCEPT OF THE ROLE OF PHYSICS VERSUS
 STUDENTS WHO DO NOT

Group	Number of Student		Total	Chi-square
	Remaining	Withdrawing		
TC	23	2	25	
LA + PL + UC	62	11	73	
Total	85	13	98	0.311
TC	23	2	25	
All But TC	146	41	187	
Total	169	43	212	2.645

Degrees of freedom = 1.

CHAPTER V

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Summary

Elementary physics is an important course in the undergraduate curriculum. It serves as an initial introduction to those who will study physics or a related discipline in depth; as a preparatory requirement for pre-professional students; and it also serves a broad general education function. Thus, physics is variously perceived as: (a) a "tool" course presenting factual information without which the student cannot expect to succeed in subsequent courses; (b) a true liberal arts discipline concerned with the codification and explanation of physical law; or (c) as a preparation for living in a technological world of ever increasing complexity.

The purpose of this study was to develop and test a preliminary form of an instrument for identifying the role of elementary physics in the undergraduate curriculum as it was perceived by students, instructors, and academic advisers associated with the course. A second objective was to determine whether or not the success of students in the study of elementary physics was related to the presence or absence of a clearly defined understanding on the part of the students of the role of elementary physics in their curriculum, and the relative agreement of students, academic advisers and physics instructors as to the role of physics in the undergraduate program. Finally, the relative success of

students who share the instructor's view of the role of physics in the undergraduate curriculum is compared with the relative success of those students who do not share their instructor's view.

A questionnaire "Physics 1114--A Topic Inventory" was developed to identify the three interpretations of the role of physics in the undergraduate curriculum; physics as a "tool" course, as a true liberal arts study, and as a preparation for life in a technological society. A panel of fourteen instructors of college-level physics assisted in the initial validation of the Topic Inventory. The Topic Inventory was administered to two hundred twelve students enrolled in Physics 1114 during the spring semester of the 1974-75 academic year, to their instructors and to thirteen academic advisers chosen from various disciplines which send significant numbers of students to the Physics 1114 course.

The semester grade together with percent of incomplete, withdrawal and unsatisfactory grades were used as measures of students' success. A qualitative analysis of the results, together with a chi-square test for significance when appropriate, were used to analyze the data collected. The null hypotheses were then rejected or not rejected on the basis of this analysis.

Conclusions

The two physics instructors and the academic advisers were in general accord as to the role of physics in the undergraduate program. Both of the instructors and 8 of the 13 academic advisers were given a TC classification; that is, they viewed elementary physics as essentially a presentation of factual information needed by the student in subsequent courses in other disciplines. The largest single group of students

with clearly defined conceptions of the role of elementary physics were classified as PL; they see physics more as a preparation for post-university life in a technical society. Nearly 65 percent of all students could not be classified in any one of the three identified conceptual groups and only 12 percent of the total student population shared the TC conceptual group with their instructors and academic advisers. It appears that, in this study, there is no general agreement between the students and their instructors or between the students and their academic advisers as to the role of physics in the curriculum.

An examination was made of the relative success rates in the study of physics for students with well-defined conceptions of the role of physics in the curriculum versus students without such well-defined conceptions. Only one of the four minor hypotheses could be rejected on the basis of the chi-square test. That is, no significant differences were found in the grade distributions, percent of unsatisfactory grades, or percent of incomplete grades for the two groups. However, students with well-defined concepts of the role of physics in the curriculum were found to have a significantly lower withdrawal rate than the remainder of the class. This is in agreement with a casual reading of Table III which shows only 10 percent of students in the combined TC, LA and PL groups withdrawing compared to about 26 percent of the remaining students.

A comparison was also made of the relative success of students who shared the instructor's conception of the role of physics (TC group) and the relative success of other groups of students in the Physics 1114 class. In this case, no significant differences were found in percent of withdrawals, percent of incompletes or percent of unsatisfactory

grades. However, the grade distributions of students in the TC group was significantly "higher" than that of other students. The chi-square calculation shown in Table XI reflects the data in Table II. Note that 36 percent of the TC students received a grade of A while none of the LA students earned an A grade and only 10 percent of the students in general received this grade.

On the basis of the study, one of the three major experimental null hypotheses and four of the minor null hypotheses can be rejected. The results are summarized as follows:

1. The two physics instructors and the academic advisers are in accord as to the role of elementary physics in the curriculum; they perceive elementary physics as a "tool" course presenting factual information without which the student cannot expect to succeed in subsequent courses.

2. There are significant differences between the way the students of physics on the one hand and their instructors or academic advisers on the other identify the role of elementary physics in the undergraduate curriculum.

3. There are no significant differences in the grade distributions in elementary physics of students with clearly defined conceptions of the role of physics in the undergraduate curriculum and students without such conceptions.

4. There are no significant differences between the numbers of students receiving satisfactory and unsatisfactory grades or the numbers of students receiving complete and incomplete laboratory grades in elementary physics when comparing students with well-defined conceptions of the role of physics in the undergraduate curriculum and students

lacking such well-defined conceptions.

5. Students with well-defined concepts of the role of physics in the undergraduate curriculum have significantly lower withdrawal rates than students without such well-defined understandings.

6. There are significant differences in the grade distributions in elementary physics of students who share the instructor's conception of the role of physics in the undergraduate curriculum and those who do not.

7. There are no significant differences between the numbers of students receiving satisfactory and unsatisfactory grades or the numbers of students receiving complete and incomplete laboratory grades in elementary physics for those who share the instructor's conceptualization of the role of the physics course and those students who do not.

8. There are no significant differences between the numbers of students withdrawing from the elementary physics course for those who share the instructor's conception of the role of physics in the undergraduate curriculum and those students who do not.

Recommendations

This was an exploratory study which gave both some expected answers and some unexpected answers. In considering these results with the view of improving instruction in elementary physics courses the following recommendations are made:

1. More precise research is needed to investigate the relationship between the students' perceptions of the role of elementary physics and their subsequent achievement. The studies should extend over a longer period of time and involve larger numbers of students and instructors.

The research instrument (the Topic Inventory) needs to be improved by adding more items and analyzing each item with appropriate statistical techniques. The term "concept" should be more fully defined and a distinction made between the student's "concept of physics" and such related variables as student interests, needs, etc.

2. There can be many types of elementary physics courses. The goals and objectives of a specific course should be carefully defined and fully communicated to instructors, academic advisers and, especially, to all students involved in the course. This action might help to decrease the numbers of students withdrawing from the course.

3. Careful consideration should be given to the feasibility and need for sectioning students on the basis of either major field of study or interests.

4. It would appear that a small but significant number of students look to elementary physics for a true liberal arts experience--a function not filled by the present course. Consideration should be given to the development of a parallel course, or special sections of Physics 1114-1214, for this purpose.

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APPENDIX A

TOPICS IDENTIFIED AS REPRESENTATIVE OF
TC, LA AND PL TYPES OF COURSE

TOPICS IDENTIFIED AS REPRESENTATIVE
OF TC TYPE OF COURSE

1. The generation and transmission of electric currents (including the nerve impulse in animals)
2. Factors affecting pressures and flow rates in fluids (both physical and biological systems)
3. The fundamentals of simple mechanical machines
4. The production and reception of sound waves (including human speech)
5. The elements of electronics and simple electronic devices
6. The mechanical properties of biological materials
7. The thermal properties of matter
8. The formulas describing the motion of objects (and the effects of forces of the motion of those objects)
9. A study of optical instruments (including the human eye)
10. A study of electro-mechanical devices (including the electric motor and the electrical generator)

TOPICS IDENTIFIED AS REPRESENTATIVE
OF LA TYPE OF COURSE

1. The evolution of man's concept of motion from Zeno to Einstein
2. The origin and structure of the universe
3. The conservation principles for energy and momentum and their relationship to underlying properties of space and time
4. Experimental attempts to verify the predictions of Einstein's theory of relativity
5. The origin (or cause) of the gravitational force
6. The "conflict" between science and humanism
7. The ultimate structure of matter; i.e., the organization and composition of electrons and protons
8. The scientific method and the discovery of physical laws
9. Probabilities, perpetual motion, and the "one-way" nature of time
10. The "true" nature of light; i.e., wave, particle or both

TOPICS IDENTIFIED AS REPRESENTATIVE
OF PL TYPE OF COURSE

1. A study of the advantages (and disadvantages) of nuclear energy production systems
2. An investigation of the origin and control of atmospheric pollution
3. The physics of alternative energy sources (including geothermal, solar, tidal, etc.)
4. The biological effects of radiation
5. A study of the physical factors limiting the production and distribution of food resources
6. An examination of techniques for evaluating the social effects of new technological developments
7. The production, use and recycling of critical mineral resources
8. The development of a national metric system of measurement
9. A review of alternative methods for dissipating waste heat energy from electrical power plants
10. Techniques and instruments for the remote sensing of earth resources

APPENDIX B

PHYSICS 1114 -- A TOPIC INVENTORY

PHYSICS 1114 -- A TOPIC INVENTORY

INSTRUCTIONS

The attached inventory is a first attempt to determine what you, as a student, feel might be the most appropriate course content for the Physics 1114. Each item in the inventory consists of two different topics which might be treated in a beginning physics course. In each case you are asked to place a checkmark (✓) in the box (□) preceding the topic which you think would be more appropriate or beneficial for you. Please note the underlined words, appropriate or beneficial, in this instruction.

Each of the individual topics appears twice in the inventory but in a different combination each time. Do not be disturbed by the recurrence of a topic. Please check one and only one topic in each item.

BIOGRAPHICAL DATA:

NAME _____

COLLEGE _____
Agri, Bus, A & S, etc.

MAJOR _____

CLASS _____
Fresh, Soph, Jr, Sr, Gr

ITEM 1:

☐ The conservation principles for energy and momentum and their relationship to underlying properties of space and time

or

☐ An investigation of the origin and control of atmospheric pollution

ITEM 2:

☐ The thermal properties of matter

or

☐ An examination of techniques for evaluating the social effects of new technological developments

ITEM 3:

☐ A study of electro-mechanical devices (including the electric motor and the electrical generator)

or

☐ The scientific method and the discovery of physical laws

ITEM 4:

☐ The "conflict" between science and humanism

or

☐ Techniques and instruments for the remote sensing of earth resources

ITEM 5:

☐ The mechanical properties of biological materials

or

☐ The physics of alternative energy sources (including geothermal, solar, tidal, etc.)

ITEM 6:

☐ The elements of electronics and simple electronic devices

or

☐ The evolution of man's concept of motion from Zeno to Einstein

ITEM 7:

☐ The biological effects of radiation

or

☐ Experimental attempts to verify the predictions of Einstein's theory of relativity

ITEM 8:

☐ The development of a national metric system of measurement

or

☐ Factors affecting pressures and flow rates in fluids (both physical and biological systems)

ITEM 9:

☐ The origin and structure of the universe

or

☐ The generation and transmission of electric currents (including the nerve impulse in animals)

ITEM 10:

☐ Probability, perpetual motion, and the "one-way" nature of time

or

☐ The production, use and recycling of critical mineral resources

ITEM 11:

☐ Techniques and instruments for the remote sensing of earth resources

or

☐ A study of optical instruments (including the human eye)

ITEM 12:

☐ The formulas describing the motion of objects (and the effects of forces on the motion of those objects)

or

☐ Probability, perpetual motion, and the "one-way" nature of time

ITEM 13:

☐ A review of alternative methods for dissipating waste heat energy from electrical power plants

or

☐ The "true" nature of light; i.e., wave, particle or both

ITEM 14:

☐ The production and reception of sound waves (including human speech)

or

☐ A study of the physical factors limiting the production and distribution of food resources

ITEM 15:

☐ The ultimate structure of matter; i.e., the organization and composition of electrons and protons

or

☐ Factors affecting pressures and flow rates in fluids (both physical and biological systems)

ITEM 16:

☐ The origin and structure of the universe

or

☐ The physics of alternative energy sources (including geothermal, solar, tidal, etc.)

ITEM 17:

☐ A review of alternative methods for dissipating waste heat energy from electrical power plants

or

☐ The fundamentals of simple mechanical machines

ITEM 18:

☐ The elements of electronics and simple electronic devices

or

☐ The origin (or cause) of the gravitational force

ITEM 19:

☐ A study of the advantages (and disadvantages) of nuclear energy production systems

or

☐ The ultimate structure of matter; i.e., the organization and composition of electrons and protons

ITEM 20:

☐ The fundamentals of simple mechanical machines

or

☐ A study of the advantages (and disadvantages) of nuclear energy production systems

ITEM 21:

☐ The "true" nature of light; i.e., wave, particle, or both

or

☐ The mechanical properties of biological materials

ITEM 22:

☐ The evolution of man's concept of motion from Zeno to Einstein

or

☐ An examination of techniques for evaluating the social effects of new technological developments

ITEM 23:

☐ An investigation of the origin and control of atmospheric pollution

or

☐ The formulas describing the motion of objects (and the effects of forces on the motion of those objects)

ITEM 24:

☐ The conservation principles for energy and momentum and their relationship to underlying properties of space and time

or

☐ The production and reception of sound waves (including human speech)

ITEM 25:

☐ A study of the physical factors limiting the production and distribution of food resources

or

☐ The scientific method and the discovery of physical laws

ITEM 26:

☐ The generation and transmission of electric currents (including the nerve impulse in animals)

or

☐ The production, use and recycling of critical mineral resources

ITEM 27:

☐ A study of optical instruments (including the human eye)

or

☐ Experimental attempts to verify the predictions of Einstein's theory of relativity

ITEM 28:

☐ The development of a national metric system of measurement

or

☐ The origin (or cause) of the gravitational force

ITEM 29:

☐ A study of electromagnetic devices (including the electric motor and the electrical generator)

or

☐ The biological effects of radiation

ITEM 30:

☐ The "conflict" between science and humanism

or

☐ The thermal properties of matter

APPENDIX C

SAMPLE OF LETTER TO PHYSICS INSTRUCTORS

April 24, 1975

A young lady (Ms. Chanpen Chuaphanich) working under my supervision on an Ed.D. Degree in Physics is completing preliminary steps in a thesis study. Specifically, she hopes to test such hypotheses as: (1) There are no significant differences between the way (a) academic advisers, (b) students and (c) instructors of elementary physics identify the role of physics in the undergraduate curriculum or (2) There are no significant differences in the success rates in elementary physics of those students who share the instructor's conceptualization of the role of physics in the curriculum and those students who do not.

As one part of her study, Ms. Chuaphanich has developed a 30 item topic inventory to identify the student's conceptualization of the role of physics in the undergraduate curriculum. This inventory has been checked by a large number of students in Physics 1114, their instructors and their academic advisers. Physics 1114 is a non-calculus course using Miller's College Physics as the text and is populated by life science, technology, and general studies students.

At the moment we are in need of a little external calibration. Would you take 10 minutes and check the enclosed inventory for us and return it in the envelope provided? We request that you specifically imagine that you are preparing to teach a non-majors course which looks at physics as "a tool course designed primarily to teach factual information without which the student cannot expect to succeed in subsequent courses in other disciplines."

Keeping this orientation in mind, please check the one topic in each of the 30 items which you consider to be the more appropriate topic for inclusion in the course.

We very much appreciate your help.

Sincerely,

D. L. Rutledge
Professor of Physics

APPENDIX D

COLLEGE PHYSICS INSTRUCTORS PARTICIPATING
IN THE STUDY

Dr. David Bowling
Central Missouri State University, Warrensburg, Missouri

Dr. Roger Hartman
Oral Roberts University, Tulsa, Oklahoma

Dr. Benny Hill
Southwestern State University, Weatherford, Oklahoma

Dr. John Layman
University of Maryland, College Park, Maryland

Dr. Whit Marks
Central State University, Edmond, Oklahoma

Dr. George C. Moore
Western Kentucky University, Bowling Green, Kentucky

Dr. Denver L. Prince
State College of Arkansas, Conway, Arkansas

Dr. Noel D. Rowbotham
College of the Ozarks, Clarksville, Arkansas

Dr. Harley D. Rutledge
Southeast Missouri State College, Cupe Girardeau, Missouri

Dr. Paul Sharrah
University of Arkansas, Fayetteville, Arkansas

Dr. Wayne Sievers
Northern Oklahoma University, Tonkawa, Oklahoma

Dr. Jim Smeltzer
Northwest Missouri State College, Maryville, Missouri

Dr. Verdine Trout
Central State University, Edmond, Oklahoma

Dr. W. R. Willis
Northern Arizona University, Flagstaff, Arizona

APPENDIX E

LETTER TO ACADEMIC ADVISERS

April 24, 1975

A young lady (Ms. Chanpen Chuaphanich) working under my supervision on an Ed.D. Degree in Physics is completing preliminary steps in a thesis study. Specifically, she hopes to test such hypotheses as: (1) There are no significant differences between the way (a) academic advisers, (b) students and (c) instructors of elementary physics identify the role of physics in the undergraduate curriculum or (2) There are no significant differences in the success rates in elementary physics of those students who share the instructor's concept of the role of physics in the curriculum and those students who do not.

As one part of her study, Ms. Chuaphanich has developed a 30 item topic inventory to identify the student's conceptualization of the role of physics in the undergraduate curriculum. This inventory has been checked by a large number of students in Physics 1114 and their instructors. Our initial results demonstrate that even such a simple instrument as this can reveal striking differences among students as to their entering expectations concerning freshman physics.

We would now like to ask you (as an academic adviser who counsels with students concerning their undergraduate programs) to take 10 minutes of your time to respond to the inventory. Specifically, we request that you check, in each of the 30 items, the one topic which you feel would be more appropriate for a student majoring in your discipline.

We appreciate your help in the study and will send you a summary of the results in mid-summer.

Sincerely,

D. L. Rutledge
Professor of Physics

APPENDIX F

LIST OF ACADEMIC ADVISERS RESPONDING
TO TOPIC INVENTORY

Murray M. Blose
Mathematics, College of Arts and Sciences

Donald W. Brown
Technology, College of Engineering

Arthur G. Carroll
Biological Science, College of Arts and Science

Calvin M. Cunningham
Biological Science, College of Arts and Science

Raymond D. Eikenbary
Entomology, College of Agriculture

John E. Harvey
Technology, College of Engineering

Jerry G. Hurst
Physical Science, College of Arts and Science

Dean W. Irby
Architecture, College of Engineering

James B. Mickle
Animal Science and Industry, College of Agriculture

Michael D. Morris
Technology, College of Engineering

Robert M. Reed
Agronomy, College of Agriculture

Jack W. Pritchard
Agricultural Education, College of Agriculture

Jerry Wilhm
Biological Science, College of Arts and Science

VITA

Chanpen Wannarat Chuaphanich

Candidate for the Degree of

Doctor of Education

Thesis: STUDENT SUCCESS IN ELEMENTARY PHYSICS VERSUS THE STUDENT'S CONCEPTUALIZATION OF THE ROLE OF PHYSICS IN THE CURRICULUM

Major Field: Higher Education

Minor Field: Physics

Biographical:

Personal Data: Born in Petchburi, Thailand, September 2, 1944, the daughter of Mr. Kasaem and Mrs. Pen Wannarat; married, Dr. Prasert Chuaphanich, May 12, 1973.

Education: Graduated from Traim-Udom Suksa School, Bangkok, Thailand in March, 1963; received the Bachelor of Education degree from Chulalongkorn University, Bangkok, Thailand, in May, 1967; received Master of Education degree from Central State University, Edmond, Oklahoma, in December, 1971; completed requirements for the Doctor of Education degree at Oklahoma State University in December, 1975.

Professional Experience: Taught in Demonstration School, Chulalongkorn University and served as student teaching supervisor of Faculty of Education, Chulalongkorn University, Bangkok, Thailand, June, 1967-July, 1970; Physics laboratory teaching assistant at Central State University, Edmond, Oklahoma, September, 1971-July, 1972; Graduate teaching assistant at Oklahoma State University, Stillwater, Oklahoma, August, 1972-July, 1975.